

CLAIMS

What is claimed is:

- 1 1. A scheduling method comprising the steps of:
2 based on scheduling states, defining a set of static schedules for an
3 application;
4 during run time, learning a cost of a set of static schedules based on
5 performance of the application; and
6 designating the static schedule with the lowest cost as an optimal
7 schedule for the scheduling state.
- 1 2. A scheduling method as claimed in Claim 1 wherein the cost of a set of static
2 schedules is learned each time there is a change in scheduling state.
- 1 3. A scheduling method as claimed in Claim 1 wherein the cost of a set of static
2 schedules is learned continuously during run time.
- 1 4. A scheduling method as claimed in Claim 1 further comprising the steps of:
2 storing a set of all possible schedules associated with each schedule state;
3 and
4 upon a change of state, selecting the optimal schedule associated with the
5 schedule state.
- 1 5. A scheduling method as claimed in Claim 4 wherein the selected schedule is the
2 schedule with the lowest cost.
- 1 6. A scheduling method as claimed in Claim 4 wherein the selected schedule is the
2 schedule with an unknown cost.

- 1 7. A scheduling method as claimed in Claim 6 wherein the schedule is randomly
2 selected dependent on utility of exploration associated with the schedule.
- 1 8. A scheduling method as claimed in Claim 1 wherein the cost of a schedule is
2 computed and stored after the schedule is executed.
- 1 9. A scheduling method as claimed in Claim 1 further comprising the step of:
2 maintaining a task execution cost for each task in the application for each
3 scheduling state.
- 1 10. A scheduling method as claimed in Claim 9 wherein an optimal static schedule
2 associated with a new scheduling state is computed using stored task execution
3 costs.
- 1 11. A scheduling method as claimed in Claim 10 wherein the cost of an individual
2 task is updated using a sliding window which discounts older execution results
3 at the expense of more recent execution results.
- 1 12. A scheduling method as claimed in Claim 10 wherein the cost of a schedule is
2 updated using a sliding window which discounts older execution results at the
3 expense of more recent execution results.
- 1 13. A scheduling method as claimed in Claim 1 further comprising the step of:
2 predicting the cost of a schedule dependent on stored task execution
3 costs.
- 1 14. A scheduling method as claimed in Claim 13 wherein a schedule is selected for
2 further exploration dependent on the predicted schedule cost.

1 15. A scheduling method as claimed in Claim 1 wherein the step of learning further
2 comprises the steps of:
3 storing application input data received during an active period in the
4 application; and
5 exploring optimal schedules while replaying the stored input data during
6 an idle period in the application.

1 16. A scheduling method as claimed in Claim 15 wherein the step of learning further
2 comprises the step of:
3 concurrently executing a copy of an application with identical input data
4 on a processor other than the processor on which the application is
5 executing.

1 17. A scheduling method as claimed in Claim 16 wherein a change in the optimized
2 schedules is immediately reflected to the schedule analyzer for use in the next
3 schedule change of the application.

1 18. A scheduling system comprising:
2 a set of static schedules for an application, the static schedules based on
3 scheduling states; and
4 a schedule analyzer which:
5 during run time, learns a cost of the set of static schedules based
6 on performance of the application; and
7 designates the static schedule with the lowest cost as an optimal
8 schedule for the scheduling state.

1 19. A scheduling system as claimed in Claim 18 wherein the schedule analyzer
2 learns the cost of a set of static schedules each time there is a change in
3 scheduling state.

- 1 20. A scheduling system as claimed in Claim 18 wherein the schedule analyzer
2 learns the cost of a set of static schedules continuously during run time.
- 1 21. A scheduling system as claimed in Claim 18 further comprising:
2 a list of schedule costs which stores an optimal schedule associated with
3 each schedule state wherein upon a change of state the schedule analyzer selects
4 the optimal schedule corresponding to the schedule state.
- 1 22. A scheduling system as claimed in Claim 21 wherein the schedule analyzer
2 selects a schedule with the lowest cost.
- 1 23. A scheduling system as claimed in Claim 21 wherein the schedule analyzer
2 selects a schedule with an unknown cost.
- 1 24. A scheduling system as claimed in Claim 23 wherein the schedule analyzer
2 randomly selects a schedule dependent on utility of exploration associated with
3 the schedule.
- 1 25. A scheduling system as claimed in Claim 18 wherein the schedule analyzer
2 computes the cost of a schedule and stores the computed cost after the schedule
3 is executed.
- 1 26. A scheduling system as claimed in Claim 18 further comprises:
2 a task execution table which stores a task execution cost for each task in
3 the application for each scheduling state.
- 1 27. A scheduling system as claimed in Claim 26 wherein the schedule analyzer
2 computes an optimal static schedule associated with a new scheduling state
3 using stored task execution costs.

- 1 28. A scheduling system as claimed in Claim 27 wherein the schedule analyzer
2 updates the cost of an individual task using a sliding window by discounting
3 older execution results at the expense of more recent execution results.
- 1 29. A scheduling system as claimed in Claim 27 wherein the schedule analyzer
2 updates the cost of a schedule using a sliding window by discounting older
3 execution results at the expense of more recent execution results.
- 1 30. A scheduling system as claimed in Claim 18 wherein the schedule analyzer
2 predicts the cost of a schedule dependent on stored task execution costs.
- 1 31. A scheduling system as claimed in Claim 30 wherein the scheduler analyzer
2 selects a schedule for further exploration dependent on a predicted schedule cost.
- 1 32. A scheduling system as claimed in Claim 18 further comprising:
2 memory which stores application input data received during an active
3 period in the application, the stored application input data allowing the schedule
4 analyzer to explore optimal schedules while replaying the application input data
5 during an idle period in the application.
- 1 33. A scheduling system as claimed in Claim 32 wherein the schedule analyzer
2 provides a copy of an application and the stored application input data for
3 concurrent execution on a processor other than the processor on which the
4 application is executing.
- 1 34. A scheduling system as claimed in Claim 33 wherein a change in the optimized
2 schedules is immediately reflected to the schedule analyzer for use in the next
3 schedule change of the application.

- 1 35. A scheduling system comprising:
2 a set of static schedules for an application, the static schedules based on
3 scheduling states;
4 means for learning which during run time, learns a cost of a set of static
5 schedules based on performance of the application; and
6 means for selecting which designates the static schedule with the lowest
7 cost as an optimal schedule for the scheduling state.
- 1 36. A scheduling system as claimed in Claim 35 wherein the means for learning
2 learns the cost of a set of static schedules is learned each time there is a change
3 in scheduling state.
- 1 37. A scheduling system as claimed in Claim 35 wherein the means for learning
2 learns the cost of a set of static schedules continuously during run time.
- 1 38. A scheduling system as claimed in Claim 35 further comprising:
2 a list of schedule costs which stores an optimal schedule associated with
3 each schedule state wherein upon a change of state the means for analyzing
4 selects the optimal schedule associated with the schedule state.
- 1 39. A scheduling system as claimed in Claim 38 wherein the means for selecting
2 selects a schedule with the lowest cost.
- 1 40. A scheduling system as claimed in Claim 38 wherein the means for selecting
2 selects a schedule with an unknown cost.
- 1 41. A scheduling system as claimed in Claim 40 wherein the means for selecting
2 randomly selects a schedule dependent on utility of exploration associated with
3 the schedule.

1 42. A scheduling system as claimed in Claim 35 wherein the means for selecting
2 computes the cost of a schedule and stores the computed cost after the schedule
3 is executed.

1 43. A scheduling system as claimed in Claim 35 further comprises:
2 a task execution table which stores a task execution cost for each task in
3 the application for each scheduling state.

1 44. A scheduling system as claimed in Claim 43 wherein the means for selecting
2 computes an optimal static schedule associated with a new scheduling state is
3 using stored task execution costs.

1 45. A scheduling system as claimed in Claim 44 wherein the means for selecting
2 updates the cost of an individual task using a sliding window by discounting
3 older execution results at the expense of more recent execution results.

1 46. A scheduling system as claimed in Claim 44 wherein the means for selecting
2 updates the cost of a schedule using a sliding window by discounting older
3 execution results at the expense of more recent execution results.

1 47. A scheduling system as claimed in Claim 35 wherein the means for selecting
2 predicts the cost of a schedule dependent on stored task execution costs.

1 48. A scheduling system as claimed in Claim 47 wherein the means for selecting
2 selects a schedule for further exploration dependent on the predicted cost for the
3 schedule.

1 49. A scheduling system as claimed in Claim 35 wherein the on-line scheduling
2 system further comprises:

3 memory which stores application input data received during an active
4 period in the application, the stored application input data allowing the
5 scheduling analyzer to explore optimal schedules while replaying the application
6 input data during an idle period in the application.

1 50. A scheduling system as claimed in Claim 49 wherein the on-line scheduling
2 system provides a copy of a copy of an application and the stored application
3 input data for concurrent execution on a processor other than the processor on
which the application is executing.

1 51. A scheduling system as claimed in Claim 18 wherein a change in the optimized
2 schedules is immediately reflected to the means for analyzing for use in the next
3 schedule change of the application.

1 52. A computer system comprising:
2 a central processing unit connected to a memory system by a system bus;
3 an I/O system, connected to the system bus by a bus interface; and
4 a scheduling system routine located in the memory system which:
5 based on scheduling states, defines a set of static schedules for an
6 application;
7 during run time, learns a cost of a set of static schedules based on
8 performance of the application; and
9 designates the static schedule with the lowest cost as an optimal
10 schedule for the scheduling state.

1 53. A computer program product for system scheduling, the computer program
2 product comprising a computer usable medium having computer readable
3 program code thereon, including program code which:

- 4 based on scheduling states, defines a set of static schedules for an
- 5 application;
- 6 during run time, learns a cost of a set of static schedules based on
- 7 performance of the application; and
- 8 designates the static schedule with the lowest cost as an optimal
- 9 schedule for the scheduling state.

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